WIND CHILL (Equivalent Temperatures)

The temperature of the air is not always a reliable indicator of how cold a person will feel outdoors. Other weather elements such as wind speed, relative humidity, and sunshine (solar radiation) also exert an influence. In addition, the type of clothing worn as well as the state of health and metabolism of an individual will have an influence on how cold he will feel. Generally, "coldness" is related to the loss of heat from exposed flesh; one can assume this coldness to be proportional to the measured rate of heat loss from an object.

A reasonably satisfactory solution to that elusive characteristic of weather known as "coldness" was first proposed by Siple in 1939. The term "wind chill" was used to describe the relative discomfort resulting from combinations of wind and temperature. The method used was not applicable to temperatures above 0° C, and high wind speeds caused exaggerated wind chill values. During the Antarctic winter of 1941, Siple and Passel developed a new formula to determine wind chill from experiments made at Little America. Measurements were made of the time required to freeze 250 grams of water in a plastic cylinder under a variety of conditions of wind and temperature. They assumed that the rate of heat loss was proportional to the difference in temperature between the cylinder and the temperature of the surrounding air. The results, expressed in kilogram calories per square meter per hour were plotted against wind speed in meters per second.

Heat loss occurs by means of radiation, conduction, and convection. Combining all effects, the general formula for heat loss H is

$$H = (A + B\sqrt{v} + Cv)\Delta t$$

where H is the heat loss (wind chill) in kg $cal/m^2/hr$,
v is the wind speed in meters per second,
Δt is the difference in degrees Celsius between neutral skin temperature of 33° and air temperature, and
Constants A, B, and C are respectively 10.45, 10.00, and -1.00.

The constant A includes the cooling caused by radiation and conduction. Also, values of A, B, and C vary widely in formulas presented by different investigators. This is to be expected since H also depends on certain properties of the body being cooled. The above formula measures the cooling power of the wind and temperature in complete shade and does not consider the gain of heat from incoming radiation, either direct or or diffuse. Under conditions of bright sunshine, the wind chill index should be reduced by about 200 kg $cal/m^2/hr$.

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, N.C. MARCH 1975
REPRINTED MARCH 1979
REPRINTED NOVEMBER 1981

The wind chill index or equivalent temperature is based upon a neutral skin temperature of 33° C (91.4° F). With physical exertion, the body heat production rises, perspiration begins, and heat is removed from the body by vaporization. The body also loses heat through conduction to cold surfaces with which it is in contact and in breathing cold air that results in the loss of heat from the lungs. The index, therefore, does not take into account all possible losses of the body. It does, however, give a good measure of the convective cooling that is the major source of body heat loss.

Figure 1 illustrates the amount of cooling produced by various combinations of wind and temperature. The line for 4 mph is accented because this is roughly the wind speed generated by someone walking briskly under calm conditions and is the generally accepted standard wind speed for calculating equivalent temperature. To obtain the temperature equivalent of 4 mph from the graph, move horizontally to the left from the intersection of a given wind and temperature until the 4 mph line is reached. The vertical line intersected is the equivalent temperature. In the example shown, a combination of 20° F temperature and a 10-mph wind has an equivalent temperature of 3° F.

Figure 2 depicts equivalent temperatures for various combinations of wind and temperature. For example, a combination of 20° F and a 10-mph wind has the same cooling power as a temperature of 3° F and a wind speed of 4 mph.

The next time you want to know how cold it is outdoors, go ahead and check that thermometer! But keep in mind that other things (wind speed, state of nourishment, individual metabolism, and protective clothing) all help to determine how "chilly" you feel at a given time and place.

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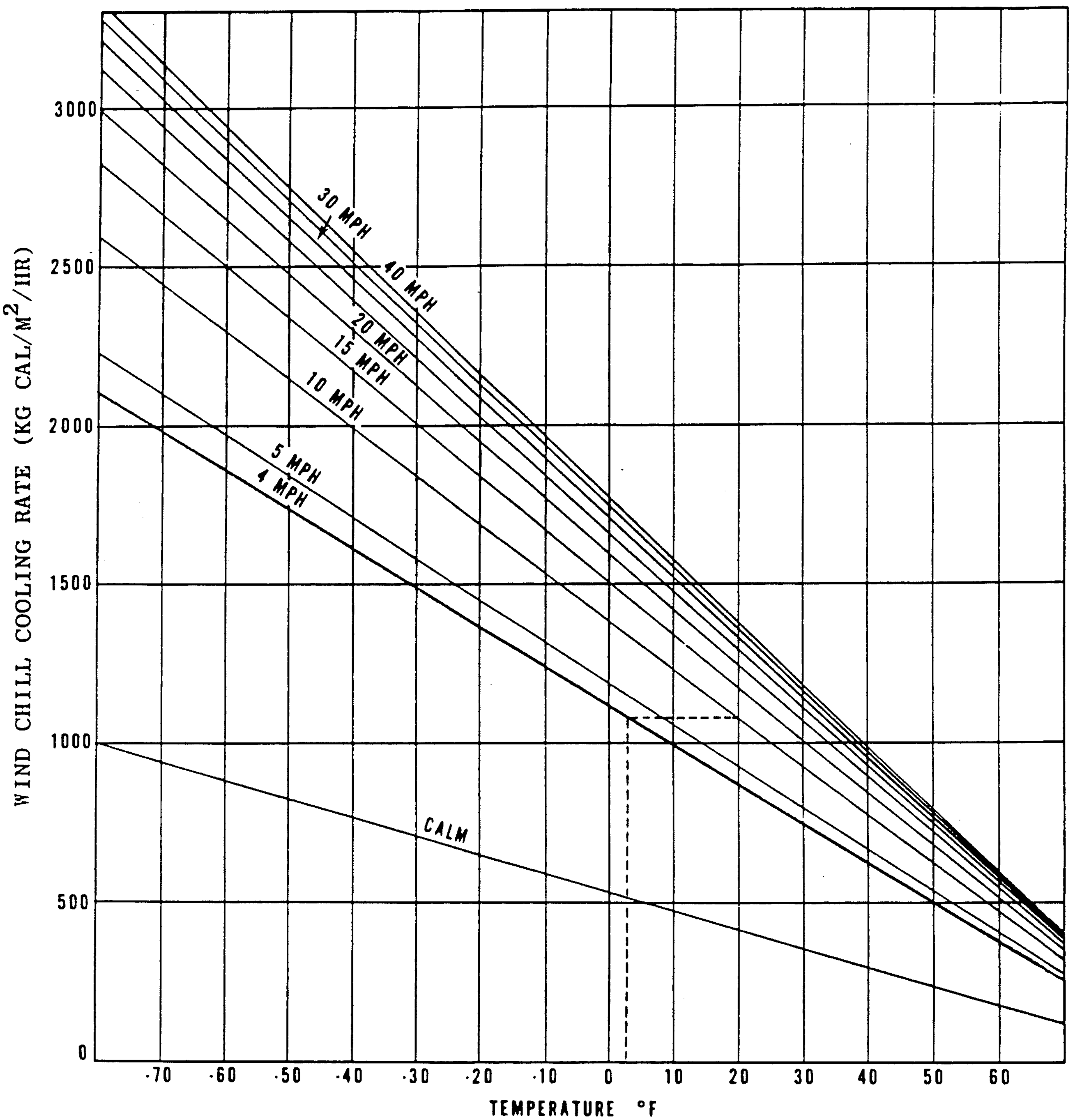

Figure 1.--Wind chill index nomogram

DRY BULB TEMPERATURE (°F)

WIND VELOCITY (MPH)	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	
4	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	4
5	43	37	32	27	22	16	11	6	0	−5	−10	−15	−21	−26	−31	−36	−42	−47	−52	5
10	34	28	22	16	10	3	−3	−9	−15	−22	−27	−34	−40	−46	−52	−58	−64	−71	−77	10
15	29	23	16	9	2	−5	−11	−18	−25	−31	−38	−45	−51	−58	−65	−72	−78	−85	−92	15
20	26	19	12	4	−3	−10	−17	−24	−31	−39	−46	−53	−60	−67	−74	−81	−88	−95	−103	20
25	23	16	8	1	−7	−15	−22	−29	−36	−44	−51	−59	−66	−74	−81	−88	−96	−103	−110	25
30	21	13	6	−2	−10	−18	−25	−33	−41	−49	−56	−64	−71	−79	−86	−93	−101	−109	−116	30
35	20	12	4	−4	−12	−20	−27	−35	−43	−52	−58	−67	−74	−82	−89	−97	−105	−113	−120	35
40	19	11	3	−5	−13	−21	−29	−37	−45	−53	−60	−69	−76	−84	−92	−100	−107	−115	−123	40
45	18	10	2	−6	−14	−22	−30	−38	−46	−54	−62	−70	−78	−85	−93	−102	−109	−117	−125	45

Figure 2.-- Wind chill equivalent temperature